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Richard V. Bovbjerg
State University of Iowa

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By Richard V. Bovbjerg

The remarkable reproductive potential of fresh-water mussels bears testimony to their rigorous conditions of existence. The external fertilization, and the parasitic larvel phase are biological hurdles to the realization of that potential, while the settling of the immature bivalves after leaving the fish host involves the many physical risks of molar action and unsuitable substratum.

Predation and disease are usual factors acting to further reduce the life expectancy of any animal but few predators are capable of utilizing adult mussels as food. Crayfish scavenge on injured or dying mussels. A snail in the stream studied, *Campeloma decisum* Say considered a detritus feeder (Bovbjerg 1952), has been observed to be present in numbers of a score or so in a partially opened mussel. Again, their role was undoubtedly that of a scavenger rather than as a predator.

The predatory role of the muskrat, *Ondatra zibethica* Linn., is not an insignificant one however. Heaps of mussel shells adjacent to burrows attest to this predation. The muskrat is, of course, common in Michigan where these studies were made and is reported from the local county (Burt, 1948); they are trapped extensively along the stream study site. These shell heaps, or "kitchen middens" have been long known and so named (Butler, 1885 and Van der Schalie, 1938). The effect of muskrat predation on the stream mussels, as measured by the middens, is the subject of this report.

The site of the study was Dickerson Creek, halfway between source and mouth, in Montcalm County, Michigan. The stream runs through glacial hills and has a gravel bed which is silted in along the depositional margins. It is approximately five meters wide and of wading depth except during spring high waters. The water has a moderate flow and is unpolluted. These conditions are favorable for the mussel populations and seven species representing six genera were present. These are:

Fusconia flava Raf.
Alasmodonta calceolus Lea
Lasmigona compressa Lea
Lasmigona costata Raf.
Lampsilis siliquoidea Barnes
Elliptio dilatatus Raf.
Strophitus rugosus Swainson.

Within a thirty meter reach of the stream, there were three well defined shell heaps. Each contained several scores of shells, some of which were complete bivalves, some of one valve only; of these, some were entire while many were fragmented. If a census could be taken of the middens, and the stream populations estimated, a comparison could reveal differential predation by species. This is the rationale of the study.

The Muskrat Midden Census and Estimate of Stream Numbers

The shell heaps were at the margins of the stream and partially submerged at summer low water levels. The concentration of shells was within one square meter; they were on the mucky margins and many of the shells were partially buried. The downstream bed of the creek was littered with largely fragmented shells, indicating a scouring of the middens during spring floods.

Several hundred shells were removed from these three middens, cleaned and sorted. Of these many were so fragmented that confident identification was impossible. These were excluded from the census. Of the 553 shells remaining, 299 were intact bivalves and the remainder right or left single valves. Since pairing of the valves would be impossible, it was determined that the total count would be comprised of the entire bivalves and the right single valves. The left single valves were excluded. The final count became 421 mussels in three middens. It is obvious that this is less than a complete census but is a large and relatively unbiased sample.

All seven of the stream's species were present. But the range in numbers per species was exceedingly wide. The most common species, *S. rugosus,* was represented by 286 shells while only one shell of *L. costata* was found. Since identification was difficult with eroded and broken shells, it was necessary to make more than one independent determination to arrive at the figures presented in Table 1.

Table 1.

Numbers and percentages of each mussel species from 90 one meter samples of the stream bed and from three muskrat shell heaps

Species Present	Stream Number	Stream Percent	Middens Percent	Middens Number
S. rugosus	148	46.4	68.0	286
L. siliquoidea	77	24.1	16.1	68
L. costata	28	8.8	0.2	1
L. compressa	26	8.1	8.8	37
F. flava	22	6.8	2.4	10
E. dilatatus	16	5.0	1.4	6
A. calceolus	2	0.6	3.1	13
Totals	319	98.8	100.0	421

The stream population was sampled by transects one meter wide. A wire frame, one meter square, was dropped on the bottom and the substratum sifted by hand to a depth of about 20 cm. The mussels removed were identified, counted and returned. Ninety samples were taken in twenty transects. On the basis of marked, released and recovered samples, the efficiency of the sampling procedure was approximately 80%. Very young specimens were not included in the sample since the error introduced would be large. The numbers of each species are tabulated in Table 1.

Comparisons of Stream and Midden Populations

All of the seven species recorded from the stream are present in the shell heaps of the muskrat; it is then safe to infer that the predator does not completely discriminate against any of the mussel species. Two species, *S. rugosus* and *L. siliquoidea,* comprise 74% of the stream population; these same two species also account for 84% of the shells in the middens. In a general sense then, the species proportions are roughly parallel. There are discrepancies, however, between the two samples. The most common species, *S. rugosus* comprises 68% of the shells in the middens but only 48% of the stream population. Conversely, *L. costata* comprises but .2% of the midden shells and is present at 8.8% in the stream population. The numbers are large and the differences significant.

One explanation of these differences would be an apparent food "preference" for one and not the other of these two mussels. However, a further observation suggests another cause for the discrepancy. Of the shells in the midden, few large individuals were recorded, indicating perhaps an inability to transport large specimens. This is in agreement with the observations of Goodrich (1932) and Van der Schalie (1938). This would account for *S. rugosus,* present in a higher percentage in the middens than in the stream; the shell of this species is very light. On the other hand, *L. costata,* a heavy shelled mussel, is almost absent from the middens. An exception to this hypothesis is the insignificant difference between the percentages of *L. siliquoidea* in midden and stream; this species has as heavy a shell as *L. costata.* In these two heavy shelled species, no shells were found in the middens which were much over half the potential size attainable by each. These data lend plausibility to the notion that, while smaller individuals of each of the seven species present may be preyed upon by the muskrat, more older and larger individuals of the thin shelled species may be transported to the burrow resulting in a larger portion of the adult population of these species becoming prey to the muskrat.

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DEPARTMENT OF ZOOLOGY
STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA